Chapter 15 Preapproved Wall Appendix: Specific Requirements and Details for KeySystem I Walls

In addition to the general design requirements provided in **Appendix 15-A**, the following specific requirements apply:

The detailed design methodology, design properties, and assumptions used by Keystone for the KeySystem I wall are summarized in the HITEC evaluation report for this wall system (**HITEC, 2000, *Evaluation of the KeySystem^{TM} I Retaining Wall*, ASCE, CERF Report 40478**). The design methodology, which is based on the Standard Specifications for Highway Bridges (**2002**) conflicts with the general design requirements in **Appendix 15-A** regarding the K value for internal stability (for the Simplified Method, Keystone recommends K of 2.0 at the top of the wall rather than 2.5), and the allowable stress for design of the steel grid reinforcement strips (Keystone recommends an allowable stress of $0.55F_y$ rather than $0.48F_y$ for design of the steel grid strip reinforcement). WSDOT does not concur with the reduced K value of 2.0. Therefore, the K value at the wall top should be 2.5 to be consistent with the AASHTO design specifications. WSDOT does concur with the use of an allowable stress of $0.55F_y$. Interim approval is given for the continued use of the AASHTO Standard Specifications as the basis for design.

Considering the currently approved block dimensions, the maximum vertical spacing of reinforcement allowed to meet the requirements in the AASHTO LRFD Specifications is 2 ft. Regarding horizontal spacing of steel grid reinforcement strips, reinforcement shall be located at a maximum spacing of every other block, as allowed by the AASHTO LRFD Specifications.

Reinforcement pullout shall be calculated based on the default values for steel grid reinforcement provided in the AASHTO LRFD Specifications. If, at some future time product and soil specific pullout data is provided to support use of non-default pullout interaction coefficients (data is provided in the HITEC report for this wall system, but different interaction coefficients were not specifically proposed), it should be noted that pullout resistance design using these product and soil specific interaction coefficients has not been calibrated using product specific data statistics and reliability theory. Therefore, the specified resistance factors in the GDM and AASHTO LRFD Specifications should not be considered applicable to product specific pullout interaction coefficients.

Concrete for dry cast concrete blocks used in the KeySystem I wall system shall meet the following requirements:

1. Have a minimum 28 day compressive strength of 4,000 psi.
2. Conform to ASTM C1372.
3. The lot of blocks produced for use in this project shall conform to the following freeze-thaw test requirements when tested in accordance with ASTM C1262:
    - Minimum acceptable performance shall be defined as weight loss at the conclusion of 150 freeze-thaw cycles not exceeding one percent of the block's initial weight for a minimum of four of the five block specimens tested.

4. The concrete blocks shall have a maximum water absorption of one percent above the water absorption content of the lot of blocks produced and successfully tested for the freeze-thaw test specified in the preceding paragraph.

It is noted in the HITEC report for this wall system that Keystone allows a dimensional tolerance for the height of the block of 1/8 inch, which is consistent with ASTM C1372, but that **Elias, et al. (2001)**, which is referenced in the **WSDOT GDM Chapter 15** and by the AASHTO Standard Specifications for Highway Bridges (**2002**) recommends a tighter dimensional tolerance of 1/16 inch. Based on WSDOT experience, for walls greater than 25 ft in height, some cracking of facing blocks due to differential vertical stresses tends to occur in the bottom portion of the wall. Therefore, blocks placed at depths below the wall top of 25 ft or more should be cast to a vertical dimensional tolerance of 1/16 inch to reduce the risk of significant cracking of facing blocks.

Block connector pins shall conform to AASHTO M 32, and shall be galvanized after fabrication in accordance with AASHTO M 111.

The steel grid ladder strips shall be transported to and handled at the project site in a manner that minimizes bending of the steel. As shipped to the wall site, the steel strips must still meet the tolerance requirements of ASTM A185 (i.e., the permissible variation of the center-to-center distance between longitudinal wires shall not exceed $\pm$0.5 inch of the specified distance).

Approved details for the KeySystem I wall system are provided in the following plan sheets. Exceptions and additional requirements regarding these approved details are as follows:

1. Immediately behind the facing blocks, either a strip of Construction Geotextile for Underground Drainage, Moderate Survivability, Class A per WSDOT Standard Specifications Section 9-33 shall be placed vertically against the blocks, with 1 ft horizontal tails placed at each reinforcement level (i.e., the geotextiles strip forms a sideways "U") shall be used (see **figures 15-(KeySystem I)-2 and 15-(KeySystem I)-3**), or a 1 ft wide column of crushed rock shall be placed as shown in Plan Sheets 3 and 5. In both cases, the purpose is to prevent movement of fines in the backfill from washing through the wall facing.
2. Any field bending of the welded wire strip reinforcement required to accommodate obstructions as shown in the attached plan sheets shall be done in accordance with WSDOT Standard Specifications Section 6-02.3(24)A "Field Bending". Any damage to the galvanizing resulting from the bending shall be repaired such that the galvanizing layer effectiveness for resisting corrosion is restored to its original condition.
3. Any adjustments to the facing batter needed during erection of the wall shall be done in a manner that prevents adding additional stress to the reinforcement-facing connection and that also prevents significant stress concentrations between the facing blocks that could cause cracking of the facing blocks as additional blocks are placed. The use of rope as shown in **Figure 15-(KeySystem I)-1** below is not acceptable as a method to adjust facing batter. In general, any shims used between blocks to adjust facing batter shall be no more than 0.125 inch thick, shall minimize the creation of local stress concentrations, and shall be made of a material that is durable and not degrade over the life of the wall.

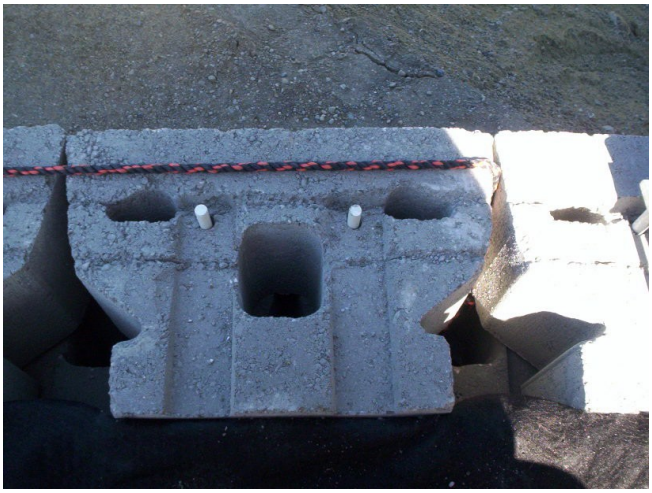


Figure 15-(KeySystem I)-1 Keystone KeySystem I block with fiberglass alignment pins.

Figure 15-(KeySystem I)-2 KeySystem I wall Keysteel reinforcement connector and block as assembled, showing both fiberglass alignment pins and galvanized steel connector pins.

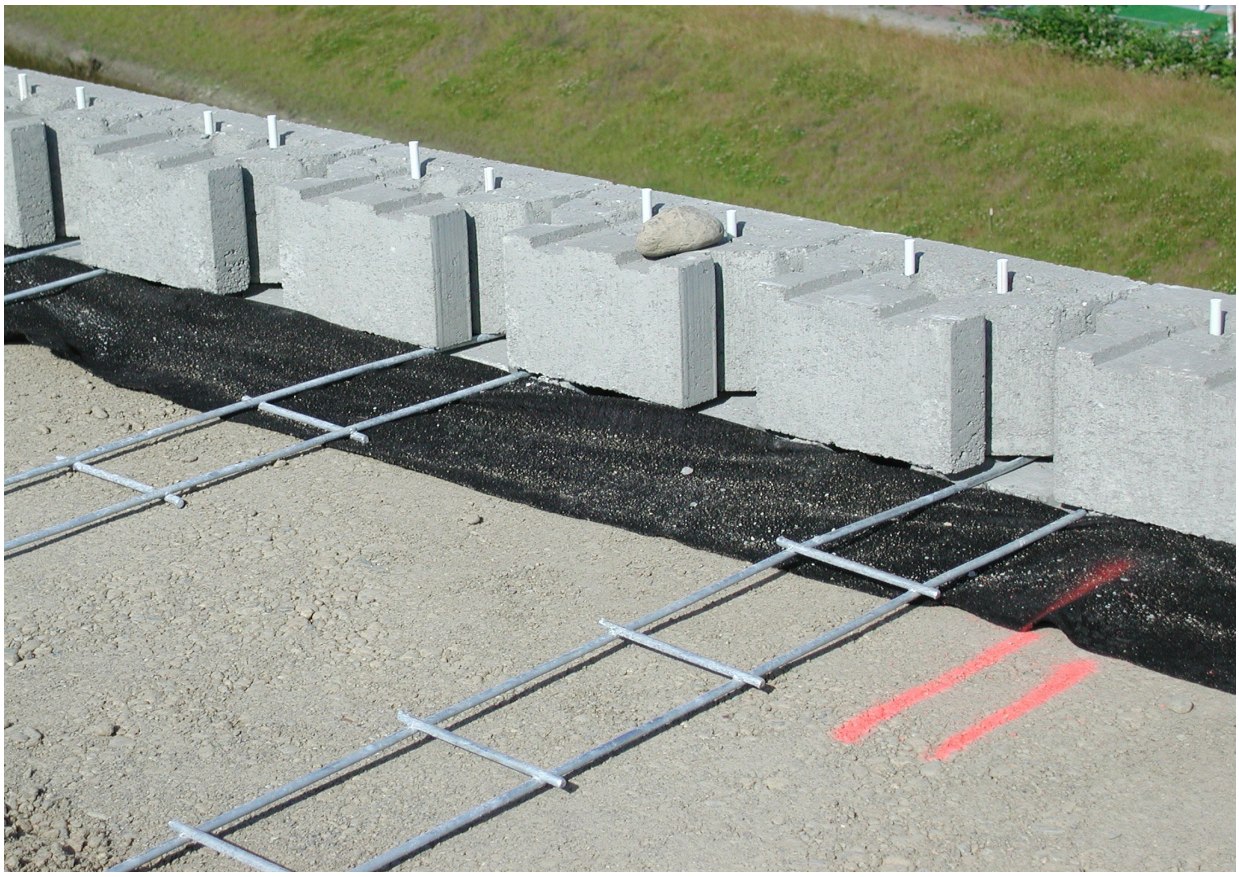
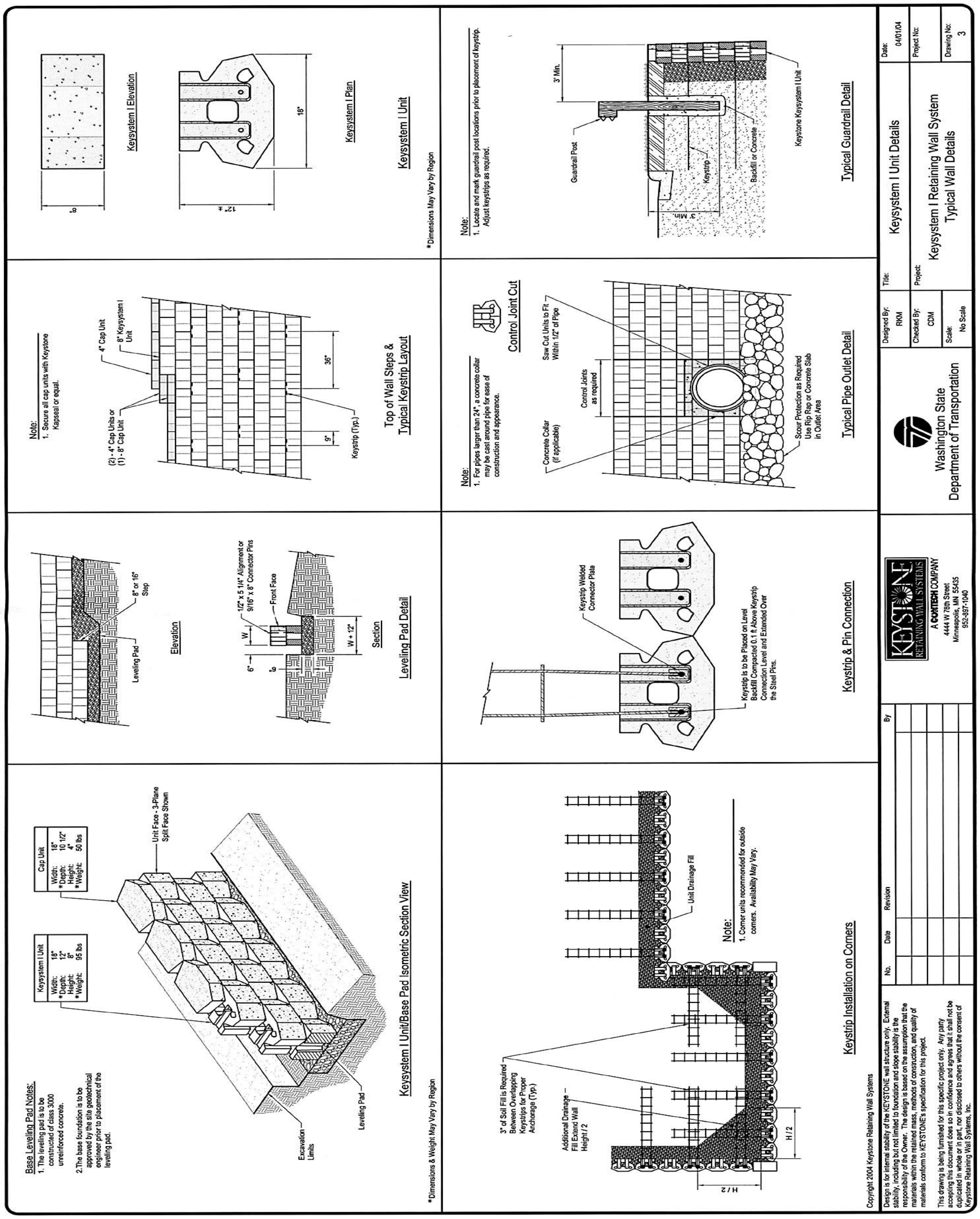


Figure 15-(KeySystem I)-3 KeySystem I wall Keysteel reinforcement connector and block as assemble, with block placed on top.


Base Leveling Pad Notes:
1. The leveling pad is to be constructed of class 3000 unreinforced concrete.
2. The base foundation is to be approved by the site geotechnical engineer prior to placement of the leveling pad.
Excavation Limits
Leveling Pad
Unit Face - 3-Plane Split Face Shown
Keysystem I Unit/Base Pad Isometric Section View
*Dimensions & Weight May Vary by Region
Elevation
Section
Leveling Pad Detail
8" or 16" Step
Front Face
Top of Wall Steps & Typical Keystrip Layout
Keystrip (Typ.)
4" Cap Unit
8" Keysystem I Unit
Keysystem I Elevation
Keysystem I Plan
Keysystem I Unit
Keystrip Installation on Corners
Unit Drainage Fill
Note:
1. Corner units recommended for outside corners. Availability May Vary.
Keystrip & Pin Connection
Keystrip Welded Connector Plate
Typical Pipe Outlet Detail
Control Joint Cut
Control Joints as required
Concrete Collar (if applicable)
Typical Guardrail Detail
Guardrail Post
Keystrip
Backfill or Concrete
Keystone Keysystem I Unit
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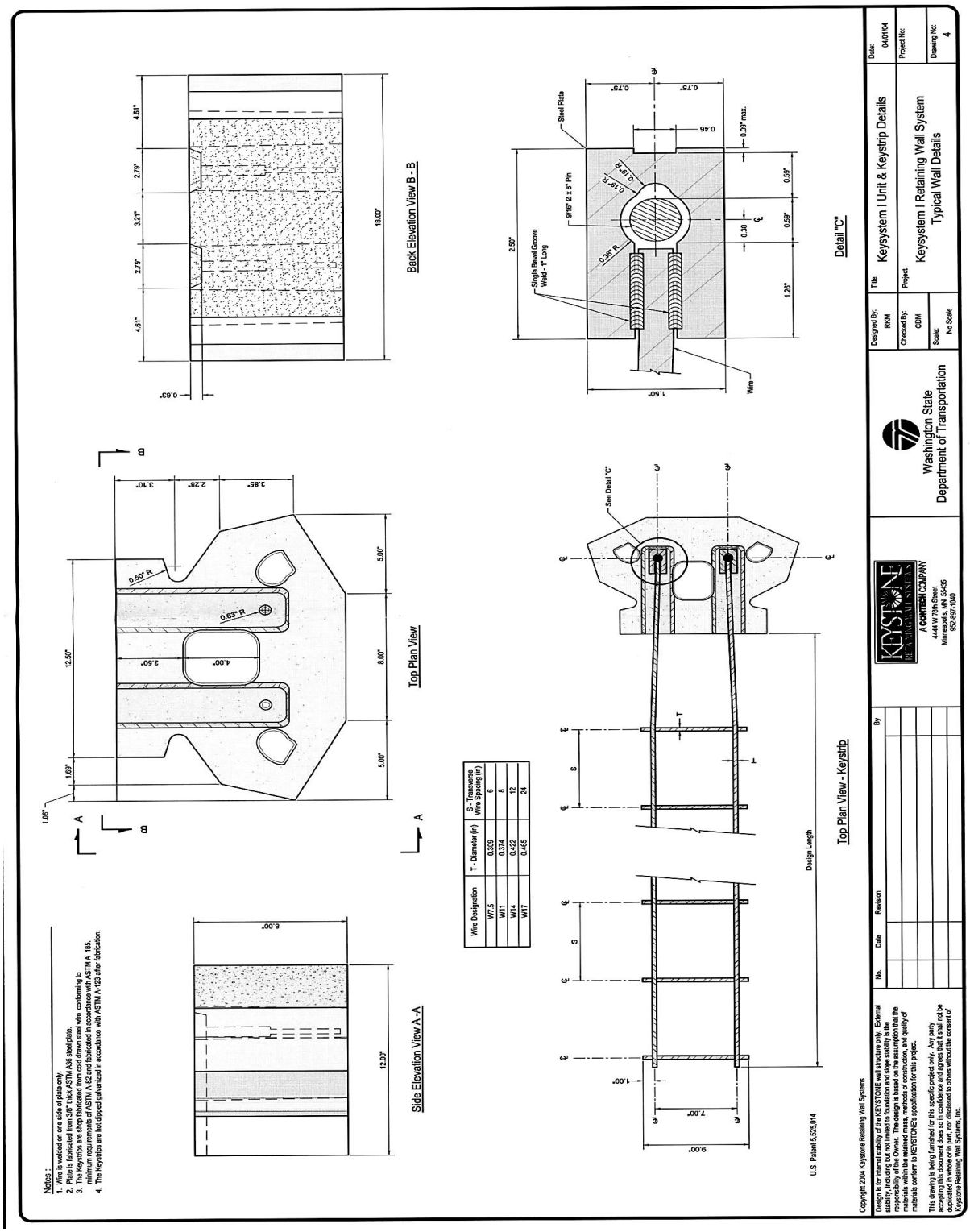
Washington State Department of Transportation
Keysystem I Unit Details
Keysystem I Retaining Wall System Typical Wall Details
No Scale


Notes :
1. Wire is welded on one side of plate only.
2. Plate is fabricated from 3/8" thick ASTM A36 steel plate.
3. The Keystrips are shop fabricated from cold drawn steel wire conforming to minimum requirements of ASTM A-82 and fabricated in accordance with ASTM A 185.
4. The Keystrips are hot dipped galvanized in accordance with ASTM A-123 after fabrication.
Back Elevation View B - B
Top Plan View
Side Elevation View A -A
Detail "C"
Top Plan View - Keystrip
Wire Designation
T - Diameter (in)
S - Transverse Wire Spacing (in)
W7.5 0.309 6
W11 0.374 8
W14 0.422 12
W17 0.485 24
U.S. Patent 5,525,014
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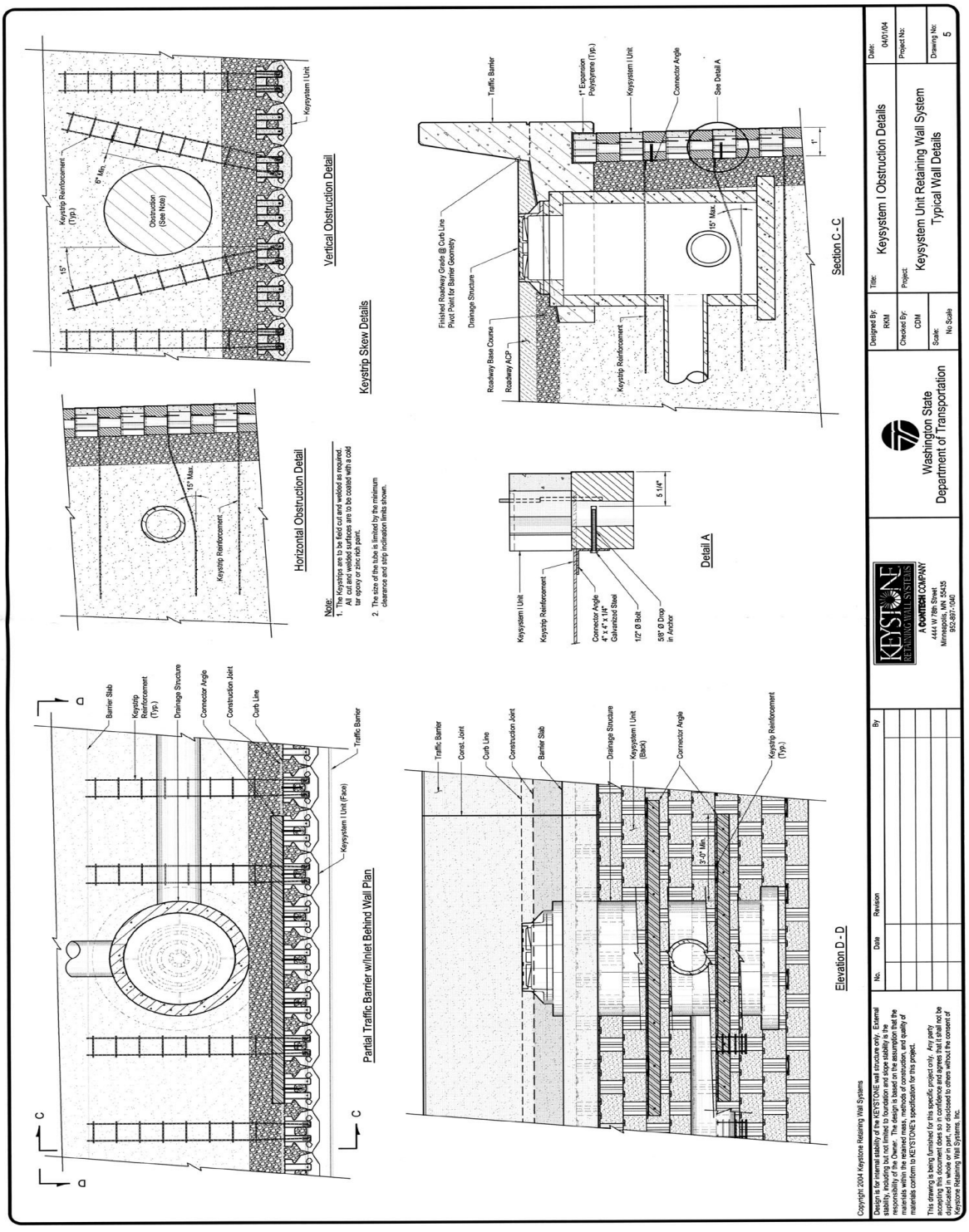
Design is for internal stability of the KEYSTONE wall structure only. External stability, including but not limited to foundation and slope stability is the responsibility of the Owner. The design is based on the assumption that the materials used in the reinforced soil mass will provide adequate quality of materials conform to KEYSTONE's specification for this project.
This drawing is being furnished for this specific project only. Any party accepting this document does so in confidence and agrees that it shall not be copied, used or disclosed in whole or part, nor disclosed to others without the consent of Keystone Retaining Wall Systems, Inc.
No. Date Revision By
KEYSTONE RETAINING WALL SYSTEMS
A CONTECH COMPANY
4444 W 78th Street
Minneapolis, MN 55435
952-897-1040
Washington State
Department of Transportation
Designed By: RKM
Checked By: CDM
Scale: No Scale
Title: Keysystem I Unit & Keystrip Details
Project: Keysystem I Retaining Wall System
Typical Wall Details
Date: 04/01/04
Project No:
Drawing No: 4


Keystrip Reinforcement (Typ.)
8" Min.
15°
Obstruction (See Note)
Keystem I Unit
Vertical Obstruction Detail
Keystrip Skew Details
Horizontal Obstruction Detail
15° Max.
Keystrip Reinforcement
Note:
1. The Keystrips are to be field cut and welded as required. All cut and welded surfaces are to be coated with a cold tar epoxy or zinc-rich paint.
2. The size of the tube is limited by the minimum clearance and strip inclination limits shown.
Traffic Barrier
1" Expansion Polystyrene (Typ.)
Keystem I Unit
Connector Angle
See Detail A
Finished Roadway Grade @ Curb Line
Pivot Point for Barrier Geometry
Drainage Structure
Roadway Base Course
Roadway ACP
Keystrip Reinforcement
15° Max.
1'
Section C - C
Keystem I Unit
Keystrip Reinforcement
Connector Angle 4" x 4" x 1/4" Galvanized Steel
1/2" Ø Bolt
5/8" Ø Drop In Anchor
5 1/4"
Detail A
Barrier Slab
Keystrip Reinforcement (Typ.)
Drainage Structure
Connector Angle
Construction Joint
Curb Line
Traffic Barrier
Keystem I Unit (Face)
Partial Traffic Barrier w/Inlet Behind Wall Plan
Traffic Barrier
Const. Joint
Curb Line
Construction Joint
Barrier Slab
Drainage Structure
Keystem I Unit (Back)
Connector Angle
Keystrip Reinforcement (Typ.)
3'-0" Min.
Elevation D - D
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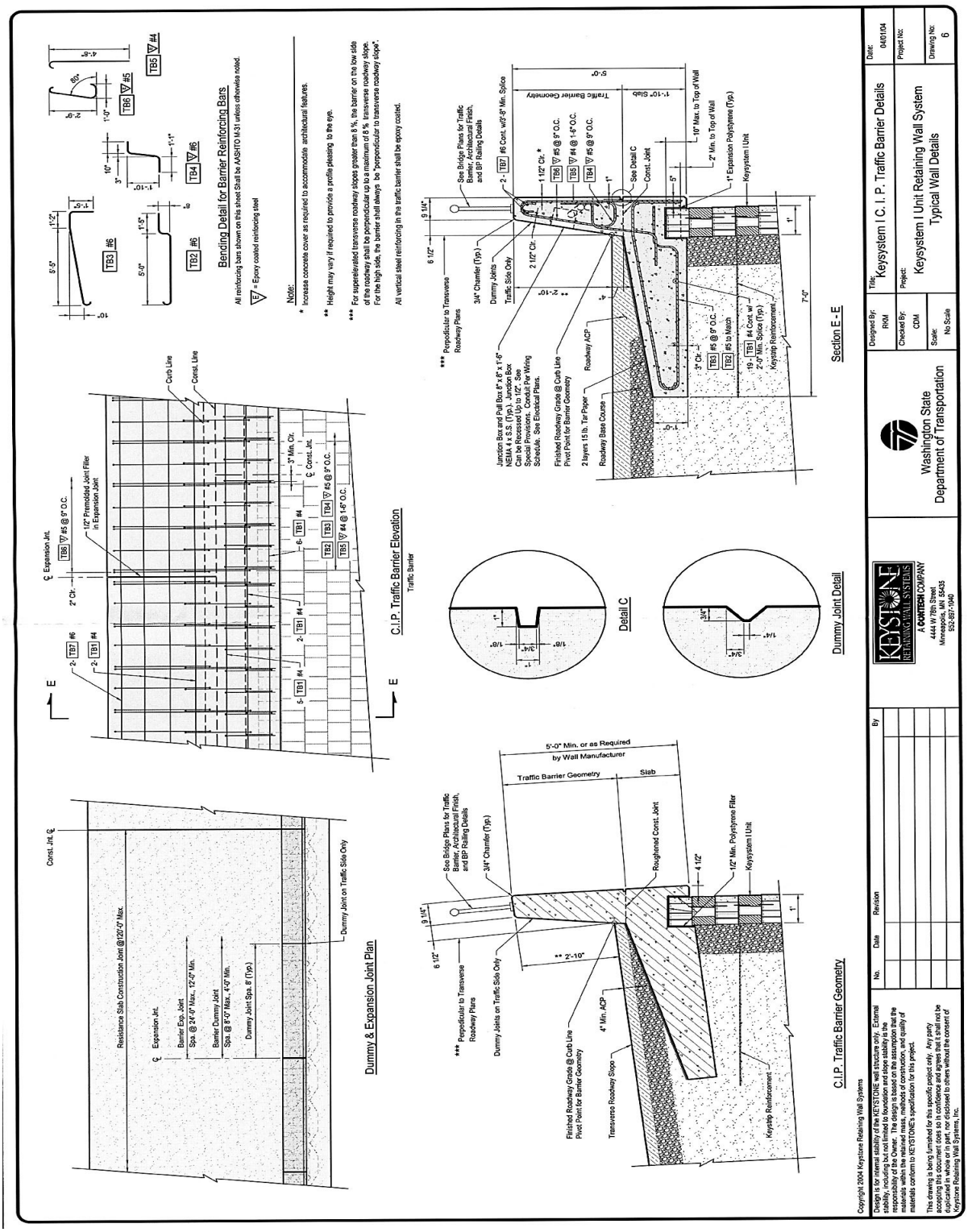
No. Date Revision By
KEYSTONE RETAINING WALL SYSTEMS
A CHEVRON COMPANY
444 W. 78th Street
Minneapolis, MN 55435
952-897-1040
Washington State Department of Transportation
Designed By: RKM
Checked By: CDM
Scale: No Scale
Title: Keysystem I Obstruction Details
Project: Keysystem Unit Retaining Wall System Typical Wall Details
Date: 04/01/04
Project No:
Drawing No: 5


Bending Detail for Barrier Reinforcing Bars
All reinforcing bars shown on this sheet Shall be AASHTO M 31 unless otherwise noted.
E = Epoxy coated reinforcing steel
Note:
* Increase concrete cover as required to accommodate architectural features.
** Height may vary if required to provide a profile pleasing to the eye.
*** For superelevated transverse roadway slopes greater than 8 %, the barrier on the low side of the roadway shall be perpendicular up to a maximum of 8 % transverse roadway slope. For the high side, the barrier shall always be "perpendicular to transverse roadway slope".
All vertical steel reinforcing in the traffic barrier shall be epoxy coated.
C.I.P. Traffic Barrier Elevation
Traffic Barrier
Dummy & Expansion Joint Plan
Detail C
Dummy Joint Detail
Section E - E
C.I.P. Traffic Barrier Geometry
Keystone Retaining Wall Systems
A CONTECH COMPANY
4444 W 78th Street
Minneapolis, MN 55435
952-897-1040
Washington State
Department of Transportation
Designed By: RKM
Checked By: CDM
Scale: No Scale
Title: Keystystem I C. I. P. Traffic Barrier Details
Project: Keysystem I Unit Retaining Wall System
Typical Wall Details
Date: 04/01/04
Project No:
Drawing No: 6
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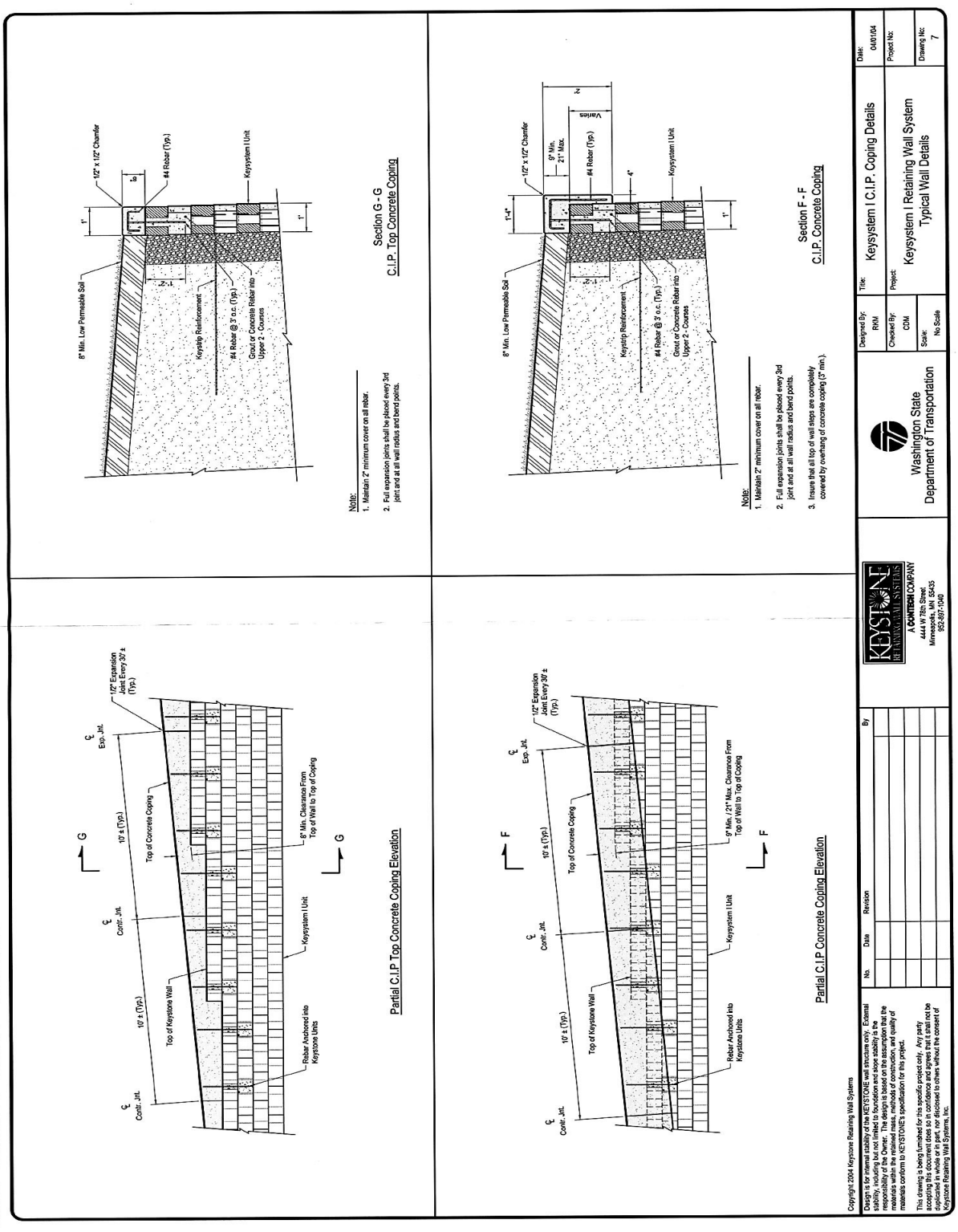
1/2" x 1/2" Chamfer
#4 Rebar (Typ.)
Keysystem I Unit
8" Min. Low Permeable Soil
Keystrip Reinforcement
#4 Rebar @ 3' o.c. (Typ.)
Grout or Concrete Rebar into Upper 2 - Courses
Section G - G
C.I.P. Top Concrete Coping
Note:
1. Maintain 2" minimum cover on all rebar.
2. Full expansion joints shall be placed every 3rd joint and at all wall radius and bend points.
Varies
9" Min.
21" Max.
Section F - F
C.I.P. Concrete Coping
3. Insure that all top of wall steps are completely covered by overhang of concrete coping (3" min.).
1/2" Expansion Joint Every 30' ± (Typ.)
Exp. Jnt.
Contr. Jnt.
10' ± (Typ.)
Top of Concrete Coping
Top of Keystone Wall
8" Min. Clearance From Top of Wall to Top of Coping
Rebar Anchored into Keystone Units
Partial C.I.P Top Concrete Coping Elevation
Partial C.I.P Concrete Coping Elevation
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No.
Date
Revision
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KEYSTONE RETAINING WALL SYSTEMS
A CONTECH COMPANY
4444 W 78th Street
Minneapolis, MN 55435
952-897-1040
Washington State Department of Transportation
Designed By: RKM
Checked By: CDM
Scale: No Scale
Title: Keysystem I C.I.P. Coping Details
Project: Keysystem I Retaining Wall System Typical Wall Details
Date: 04/01/04
Project No:
Drawing No: 7